Sensors & Automation

Sensors & Automation Annual Report

Fiscal Year 2003

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry
through imporvements in energy and environmental performance

U.S. Department of Energy
Energy Efficiency and Renewable Energy

Industrial Technologies Program — Boosting the Productivity and Competitiveness of U.S. Industry

Industry consumes 33 percent of all energy used in the United States. By developing and adopting more energy efficiency technologies, U.S. industry can boost its productivity and competitiveness while strengthening national energy security, improving the environment, and reducing emissions linked to global climate change.

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) works in partnership with U.S. industry to increase the efficiency of energy and materials use, both now and in the future. Through an innovative strategy known as Industries of the Future (IOF), EERE's Industrial Technologies Program (ITP) seeks to improve the energy intensity of the U.S. industrial sector through a coordinated program of research and development (R&D), validation, and dissemination of energy efficiency technologies and operating practices. ITP develops, manages, and implements a balanced portfolio that addresses industry requirements throughout the technology development cycle. The primary long-term strategy is to invest in high-risk, high-return R&D. Investments are focused on technologies and practices that provide clear public benefit but for which market barriers prevent adequate private-sector investment.

The IOF strategy maximizes the energy and environmental benefits of ITP's process-specific technology investments by forming collaborative partnerships with energy–intensive industries. These collaborations aim to effectively plan and implement comprehensive R&D agendas and help disseminate and share best energy management practices throughout the United States. ITP focuses its resources on a small number of energy-intensive materials and process industries that account for over 75 percent of industrial energy consumption:

- Aluminum
- Chemicals
- Forest Products
- Glass
- Metal Casting
- Mining
- Petroleum Refining
- Steel

ITP also conducts R&D projects on enabling technologies that are common to many industrial processes such as industrial energy systems, combustion, materials, and sensors and process control systems. Technological advances in these crosscutting areas can facilitate the development of revolutionary new alternatives to conventional manufacturing processes in the IOFs, as well as contribute to incremental improvements in energy efficiency. In addition, ITP funds technical assistance activities to stimulate near-term adoption of best energy-saving technologies and practices within industry. These activities include plant assessments, tool development and training, information dissemination, and showcase demonstrations.

New technologies that use energy efficiently also lower emissions and improve productivity. By leveraging technical and financial resources of industry and government, the IOF partnerships have generated significant energy and environmental improvements that benefit the nation and America's businesses. Energy-intensive industries face enormous competitive pressures that make it difficult to make the necessary R&D investments in technology to ensure future efficiency gains. Without a sustained commitment by the private and public sectors to invest in new technology R&D and deployment, the ability to close the gap between U.S. energy supply and demand will be severely compromised.

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ON THE COVER: The cover features a laser ultrasonic-based gauge for on-line measurement of wall thickness and eccentricity of steel tubing. The gauge represents a significant accomplishment for the Sensors & Automation (S&A) initiative, which is part of the Office of Energy Efficiency and Renewable Energy's Industrial Technologies Program (ITP). To develop the gauge, S&A partnered with The Timken Company, a manufacturer of highly engineered bearings and alloy steels, based in Canton, OH. Timken managed a multi-disciplinary team to develop the system. The project was completed in Fiscal Year 2003.

The cover image shows a blue inspection head ready to inspect an incoming red hot tube. The head contains the optical elements that deliver and collect laser light and other signals that are processed into the tube wall thickness, measurement position, and temperature. The insert in the lower right shows a display screen with generated data plotted against the measurement location along the tube length. Also displayed are computed statistical data and order information for each tube as it is processed.

In its first two years of operation (March 2002 through March 2004), the system inspected over 750,000 tubes and demonstrated excellent reliability and performance. The gauge routinely provides in-process feedback that is used to recommend mill adjustments resulting in a higher quality product with less wall variation. Scrap and rework are at record low levels. Energy savings in tube making due to use of this system have been estimated at 5 percent, or 23 billion BTUs annually. This laser-based gauge is another example of how ITP boosts the productivity and competitiveness of U.S. industry.

EXHIBITS

EXECUTIVE SUMMARY

A Successful Partnership with Industry

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) leads the federal role in developing advanced energy-efficient and environmentally friendly industrial technologies. Crosscutting R&D in sensors and automation is a component of the overall EERE strategy and contributes to the goals outlined in the National Energy Policy. Advanced sensors and controls can provide data that enable an operator to consistently optimize production processes. Measurement and control systems that permit continuous process operation will aid industry in its push for higher productivity and efficiency. For example, real-time process monitoring and control systems will enable high-speed, precision forming operations to increase their efficiency and the quality of the final product, reducing the amount of rejected product that must be reworked.

The EERE Industrial Technologies Program (ITP) directs the Sensors & Automation (S&A) activity, which seeks to increase the energy efficiency of energy-intensive industrial processes by investing in the development of technologies that are applicable across multiple industries. S&A collaborates with the Industries of the Future (IOF) on technologies addressing some of the most pressing fundamental measurement and control needs faced by industry. This collaboration allows the initiative to leverage its resources while helping to develop a core set of enabling technologies for energy-intensive industries.

Sensors & Automation Strategy

The Sensors & Automation activity supports a diverse portfolio of cost-shared, crosscutting research addressing technological needs that have broad applicability throughout the industrial sector. S&A leads ITP in providing advanced measurement and control technology solutions to meet the needs of all industry sectors supported by the IOF strategy.

> *The goal of ITP's Sensors & Automation portfolio is to identify, develop, and deploy integrated measurement systems for operator-independent control of manufacturing processes that can be used by more than one industry and are fully compatible with the harsh industrial environment. Ultimately, systems will enable a level of productivity and quality currently unattainable under human or machine control and produce a gain of 5 percent in energy efficiency.*

S&A's research activities are organized into the following categories: advanced sensors, next-generation controls, information processing, and wireless technologies. Automation and robotics—two focus areas of the portfolio—are included here under the category of controls.

Sensors & Automation directly supported 11 projects in FY 2003. In addition, the portfolio has either co-funded or directed other projects in the portfolios of the various IOFs. S&A also has responsibility for a number of Small Business Innovation Research (SBIR) projects in the sensors and control area. More information about the Sensors & Automation portfolio is available on the ITP Web site at http://www.oit.doe.gov/sens_cont/portfolio.shtml.

The following briefly summarizes major highlights and accomplishments during 2003:

FY 2003 Highlights

- **Laser Ultrasonic Measurement System** – A laser-based ultrasonic tube wall thickness gauge installed at the Timken Company's #4 mill has verified the quality of over 600,000 tubes produced since March 2002. The amount of out-of-spec product has been reduced to record low levels, leading to savings of more than 50 billion Btus worth hundreds of thousands of dollars.

- **Diode Laser Sensor for Combustion Control** – A tunable diode laser sensor for detecting temperature, NO_x levels, and CO levels in harsh furnace environments was successfully demonstrated at several steel and aluminum industry host sites.

- I**n-Situ, Real-Time Measurement of Melt Constituents –** A laser-induced breakdown spectroscopy technology that measures melt constituents in-situ and in real-time was demonstrated at an aluminum plant and additional applications are anticipated in the glass, steel, and utility (coal-burning power plants) industries.

- **Intelligent Extruder –** A software system for monitoring and controlling extruders used in polymer injection molding has been validated using commercial production rate data, demonstrating that the system's diagnostics and control concepts are scalable to production-scale operations.

- **Wireless Telemetry for Industrial Applications** – A dynamically reconfigurable wireless network architecture that provides standardized communication protocols and data structures has been demonstrated in both a steel mill and a paper mill.

- **Fiber-Optic Sensor for Industrial Process Measurement and Control** – A prototype tunable diode laser absorption spectroscopy instrument for practical use in combustion applications was tested in a 1.5 MW boiler. The new sensor has also been successfully used to measure the temperature required in the production of fiber optic cable.

- **Cavity-enhanced Gas Analyzer for Process Control Applications –**An ultrasensitive, cavity-enhanced absorption process has been developed as an alternative to gas chromatography for measuring acetylene contamination during ethylene production. Field testing of the new technology has yielded accurate and reproducible measurements of acetylene content.

- **Broadly Tunable Mid-Infrared Hydrocarbon Sensor** – A broadly tunable, mid-IR laser spectrometer that can be used in the chemical industry for species concentration measurement has been developed. The measurements taken by the sensor can be used for both process control and environmental monitoring.

- **Analysis of the Current State of the Art in Controls, Automation, Robotics and Information Processing –** Sensors & Automation has conducted a broad analysis of the current state of the art in these four areas to further refine its strategy and determine where the best industrial research opportunities exist. Teams of experts in each area have identified opportunities where significant energy savings and productivity improvements could be achieved and characterized the applicable industries and potential benefits.

- **Vision for Industrial Wireless Technology –** Representatives of the extended industrial wireless community and DOE have cooperatively developed *Industrial Wireless Technology for the 21st Century*, a unified vision for the future of this rapidly evolving technology. The vision defines specific goals and challenges, provides some context for non-experts, and maps out the key hurdles to fully exploiting wireless capabilities in industrial environments.

- **WINA Strategy Workshop —** Sensors & Automation is assisting suppliers and end users of industrial wireless technology with the creation of WINA, the Wireless Industrial Networking Alliance. WINA's major objective is to promote the adoption of wireless networking technologies and practices that will help increase industrial productivity and efficiency. In September 2003, a representative of Sensors & Automation participated in the first WINA strategy workshop, where more than 35 end users, suppliers, system integrators, and other stakeholders came together to help devise a strategy to increase industrial adoption of wireless technology.

- **Sensors & Automation Solicitation —** A solicitation entitled "Sensors, Controls, and Automation Crosscutting Technologies" was issued on January 15, 2003 (the solicitation closed April 16, 2003). In August, five projects with a total value of $33 million were selected for negotiation.

OVERVIEW OF INDUSTRIAL MEASUREMENT AND CONTROL

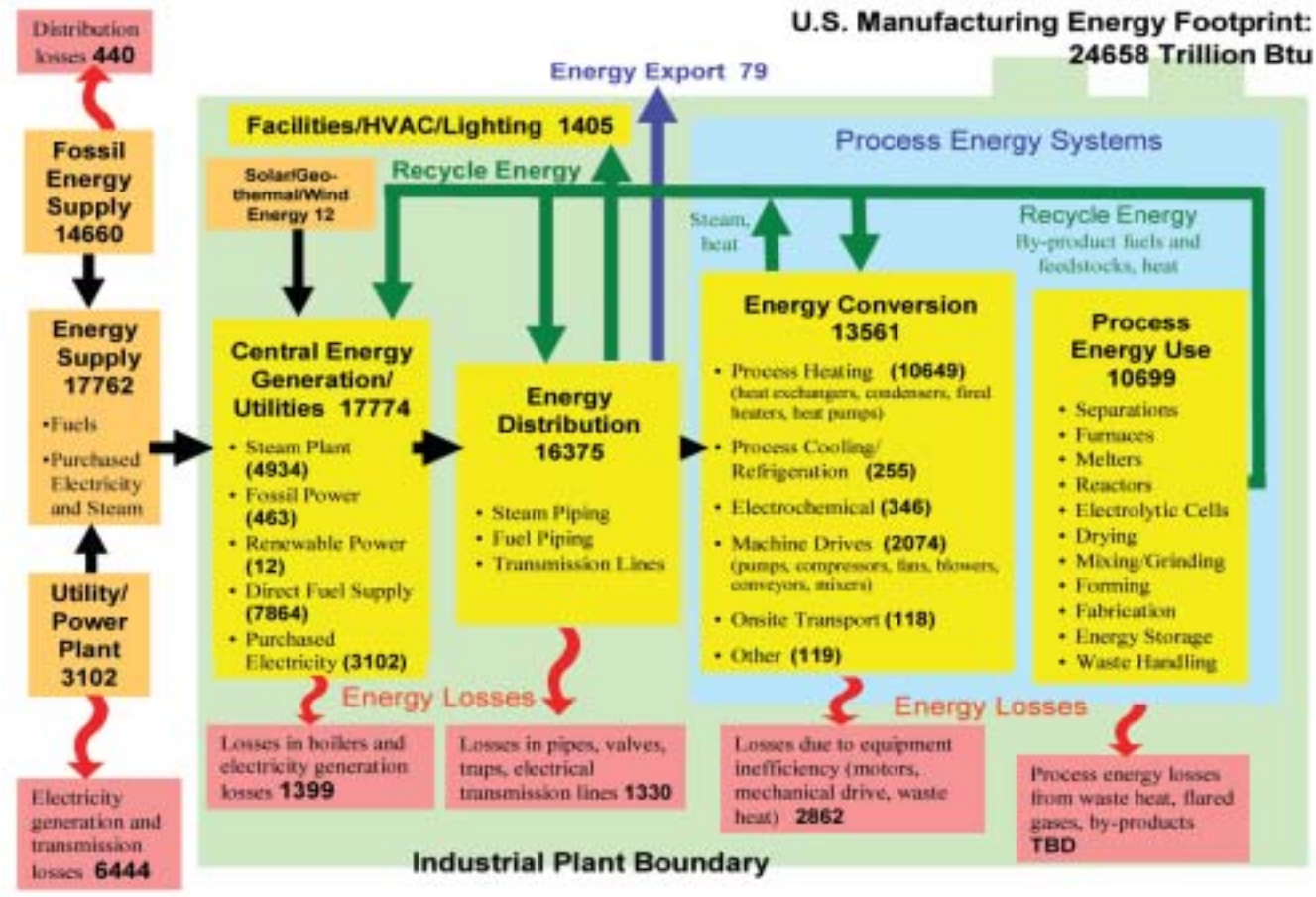
Measurement and control systems are integral components of virtually every industrial process and are essential to the proper operation and profitability of the process industries. Intelligent control systems and process automation help manufacturers improve plant energy efficiency and boost productivity by increasing throughput, yield, and product quality. Other benefits include enhanced worker safety and decreased generation of waste products and pollutants.

The United States is both the largest provider of and the largest single national market for measurement and control products and services. Approximately 1,000 manufacturers and distributors of sensor and control equipment currently exist in the United States. Total employment of these companies exceeds 50,000, with a payroll of more than $2 billion per year. The market for process controls is valued annually at approximately $26 billion worldwide; the total value of U.S. shipments was $9 billion in 2002, with process industries accounting for about 70 percent (more than $6 billion).

Energy Use

Energy end-use patterns can be illustrated through the use of an energy footprint, shown in Exhibit 1, which identifies energy use and losses due to equipment and system inefficiencies for the entire industrial sector. Within the boundary of the manufacturing plants themselves, nearly 40 percent of energy delivered is lost prior to being used in specific processes. Close to 3,000 trillion Btus (3 quads) of energy are lost in energy conversion processes (e.g., process heating equipment, motors) and an unknown additional amount is lost in manufacturing processes. These are the areas where Sensors & Automation can help industry make meaningful gains in energy efficiency.

Exhibit 1
Energy Footprint of the U.S. Industrial Sector



THE CHALLENGE

The entire manufacturing industry needs intelligent control systems to improve their resource efficiency and product quality, as well as to minimize generation of waste and pollutants. The economic impact of measurement and control technology products reaches beyond the industry sectors where these products are applied.

Many challenges exist to developing advanced measurement and intelligent control systems that meet end-user manufacturers' needs and that will be embraced by end users. These challenges cover performance characteristics of the technologies themselves as well as commercialization hurdles:

Performance Characteristics
- proven operational reliability and sustained performance in harsh environments
- robustness and general utility
- real-time capability and the need for faster and more discriminating sensors to take advantage of today's processing power
- value to the customer and payback period
- physical size
- invulnerability to interference and security (for wireless technologies)

Commercialization Hurdles
- lack of awareness of the value of sensor data, particularly in preventing unplanned maintenance
- lack of awareness that sensors can give greater capabilities to older equipment, thereby decreasing maintenance costs

Industry's Reliance on Sensors and Controls

Sensors and control systems are integral components of virtually every industrial process and are essential to the proper operation and profitability of the Industries of the Future. Intelligent control systems and process automation help manufacturers improve plant energy efficiency and boost productivity by increasing throughput, yield, and product quality. Other benefits include enhanced worker safety and decreased generation of waste products and pollutants.

Strategy for Improving Industrial Energy Efficiency through Sensors & Automation

The U.S. Department of Energy's (DOE) Office of Energy Efficiency and Renewable Energy (EERE) leads the federal role in developing advanced energy-efficient and environmentally friendly industrial technologies. Sensors & Automation is part of the EERE Industrial Technologies Program, which seeks to boost the efficiency and productivity of the energy-intensive industries.

Sensors & Automation directly sponsors the development of integrated measurement systems for operator-independent control of manufacturing processes with broad applicability across multiple industry sectors. S&A also collaborates with the seven IOFs to co-fund sensors and controls research for these industries.

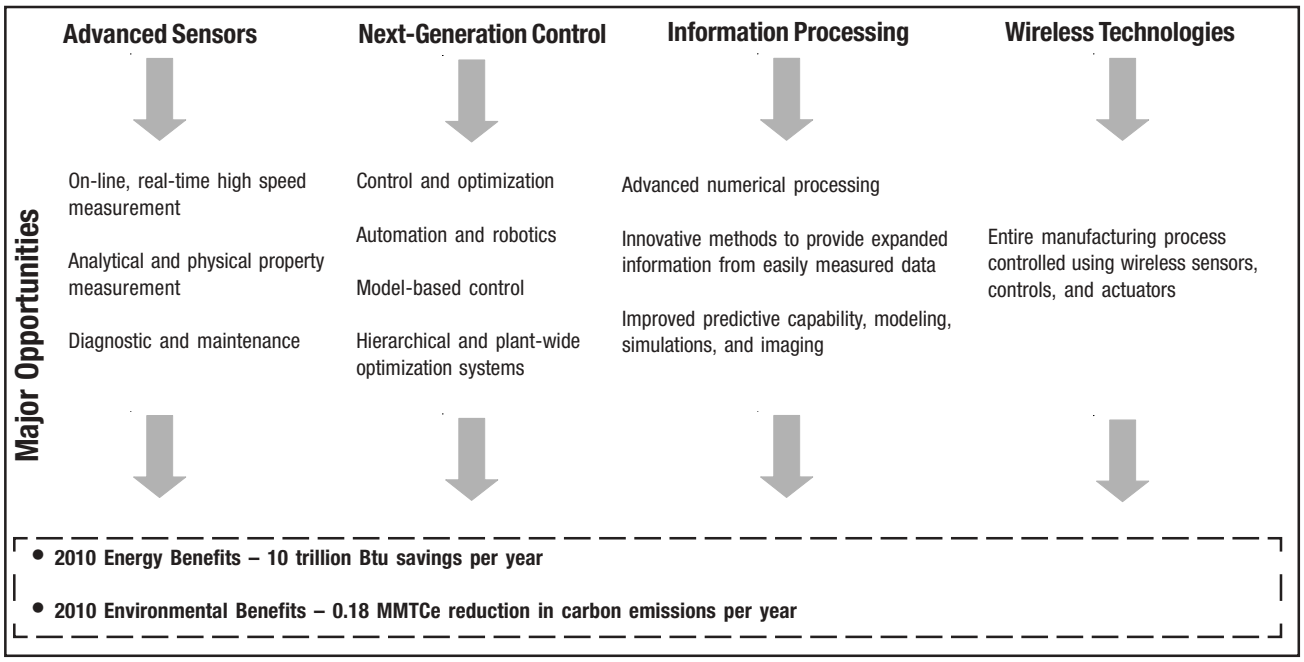
The roadmaps of seven Industries of the Future identify improved sensors and controls as one of the highest priority industry needs for increasing manufacturing energy efficiency. The projects supported by S&A address the broad sensor, control, and automation priority needs identified in these IOF technology roadmaps. Over the last several years, increasing emphasis has been placed on seeking projects to develop sensor, controls, and automation technologies capable of revolutionizing the manufacturing processes used by the IOFs, thereby saving even more energy.

An area that received additional emphasis in FY 2003 was industrial wireless telemetry. Wireless sensor systems hold the potential to help U.S. industry use energy and materials more efficiently, lower production costs, and increase productivity. In December 2002, the vision document *Industrial Wireless Technology for the 21st Century* was published. The goal of DOE's industrial wireless initiative is to develop a non-proprietary, open architecture wireless network and evaluate the network in an industrial production facility. This

network will replace the wires now used in sensor and control systems and will allow operational approaches not now practical, such as ubiquitous sensing. The target markets of this technology include the IOFs as well as other manufacturing industries. Three new wireless technology projects were among those selected for negotiation in the S&A's FY 2003 solicitation.

The Sensors & Automation strategy is designed to have the greatest impact on reducing industrial energy intensity. The strategy evolves over time as R&D projects are funded and completed, as new opportunities to have a significant impact on the industry are identified, and as national priorities change. S&A currently organizes its research portfolio into four categories: Advanced Sensors, Next-Generation Controls, Information Processing, and Wireless Technologies. Automation and robotics—two focus areas of the portfolio—are included under the category of Next-Generation Controls. Exhibit 2 presents the major opportunities within each of these four categories.

Exhibit 2
Sensors & Automation Targets for Energy Efficiency



The portfolio includes high-risk, high-return R&D projects addressing needs that cut across multiple industry segments. Projects typically run 3-4 years and are cost-shared by the technology developer (private research companies, technology suppliers, and universities). A steering committee comprised of representatives from the IOFs and other experts provides direction and guidance. End-user industry involvement in demonstrating the technical feasibility of the technologies accelerates the dissemination of research results and technology transfer. In FY 2003, S&A had 11 active projects and additionally co-funded other projects with various IOFs. Five additional projects (with a total value of $33 million) were selected for negotiation as a result of the FY 2003 solicitation.

In FY 2003, S&A revised its strategy to ensure that it will help meet the measurement and control needs of the IOFs without neglecting the development of fundamentally new concepts that could revolutionize how measurement and control functions are performed throughout the industrial sector. Accordingly, the portfolio will include three types of research projects, as shown in Exhibit 3.

Either of the first two types of research projects shown in Exhibit 3 may be in support of IOF Grand Challenges (large, high-risk projects developing revolutionary technologies to dramatically decrease energy intensity).

Exhibit 3
Types of Sensors & Automation Research Projects Supported by DOE/ITP

Type of Research Project	Project Funding Lead	Project Technical Lead
Industry-specific	IOF	IOF
Improvements to existing systems that benefit multiple industries	Could be S&A funds only or co-funding with other IOF areas	IOF(s)
New concepts for nest generation sensors and automation	S&A	S&A

In line with this new strategy, S&A issued a solicitation entitled "Sensors, Controls and Automation Crosscutting Technologies" on January 15, 2003 (the solicitation closed April 16, 2003). Through this solicitation, DOE will be awarding a total of $16 million to selected research projects over a 5-year period. With the required minimum 50 percent non-federal cost-share, the total value of projects undertaken could reach $33 million. The solicitation addressed two separate topics: crosscutting sensors and controls and industrial wireless telemetry. The first topic covers sensor and control technologies that benefit multiple industries, while wireless telemetry represents a new concept for the next generation of sensor and control systems. Five organizations were selected for negotiation in August 2003.

To assure broad participation, S&A's solicitations are announced in trade society publications, Web sites, and meetings, the *Commerce Business Daily*, *FedBizOpps*, and the Sensors & Automation Web site. Selection of projects follows merit-based criteria that emphasize projected energy, environmental, and economic benefits based on sound analysis using a standardized procedure available in the on-line Project Evaluation Tool (http://www.energetics.com/sensorstool). This rigorous solicitation development and implementation process ensures targeted, competitive solicitations for pre-competitive R&D.

S&A initiated a broad analysis of the current state of the art in controls, automation, robotics and information processing (the sensors area was the focus of a similar study conducted in FY 2002) to further refine its strategy and identify the best industrial research opportunities for S&A in these four areas. The overall effort is comprised of study teams of experts working independently in each of the four areas, coordinated by Dr. Frank Doyle of the University of California at Santa Barbara. Each team of experts has:

- Identified opportunities for DOE/ITP research funding with the Industries of the Future, prioritized by energy savings and energy efficiency
- Developed two to three case studies that could contribute to the solution to specific Grand Challenges
- Identified recent and ongoing projects in related efforts, key funding agencies, and major contractors (e.g., National Institute of Science and Technology)

FY 2003 HIGHLIGHTS & ACCOMPLISHMENTS

Sensors & Automation supports a diverse portfolio of cost-shared research that address high-risk, high-impact needs that have a broad application throughout multiple industries. In FY 2003, S&A's portfolio included 10 active projects, seven of which were completed that year (see Exhibit 4, which also indicates the relevant IOF). S&A also co-directed four Phase II Small Business Innovation Research (SBIR) grant projects (Exhibit 5). In addition, over 40 projects in the areas of sensors and controls that are funded by other ITP IOFs are shown in Exhibit 6.

Fact sheets describing projects in the Sensors & Automation portfolio are located on the DOE/ITP Web site at http://www.oit.doe.gov/sens_cont.

In addition to sponsoring R&D, Sensors & Automation achieved a number of noteworthy accomplishments in FY 2003. These accomplishments are described below:

Exhibit 4
Active Sensors & Automation Projects in FY 2003

- Development of a Versatile Laser Ultrasonic System and Application to On-Line Measurement for Process Control (Steel)*
- In-Situ, Real-Time Measurement of Melt Constituents in the Aluminum, Glass, and Steel Industries
- Integrated Industrial Process Sensing and Control System Applied to and Demonstrated in Cupola Furnaces (Metalcasting)*
- Intelligent Extruder (Chemicals)*
- Thermal Imaging Control of Furnaces and Combustors (Steel & Glass)
- Wireless Telemetry for Industrial Applications (All IOF Industries)*
- Diagnostics and Control of Natural Gas-Fired Furnaces via Flame Image Analysis Using Machine Vision and Artificial Intelligence Techniques
- Remote Automatic Material On-Line Sensor (Forest Products)
- Solid State Sensors for Monitoring Hydrogen (Chemicals)
- Tunable Diode Lasers Sensors for Monitoring and Control of Harsh Combustion Environments

** Project was successfully completed in FY 2003*

R&D Highlights

Laser Ultrasonic Measurement System – A team headed by The Timken Company has successfully developed and is now routinely using laser-generated ultrasound to determine the thickness of hot seamless steel tubing. Laser-generated ultrasound replaces radiation-type gauges and makes manual micrometer measurements obsolescent. Ultrasound is induced in hot steel tubing using fiber-coupled laser light with return echoes detected using laser-based interferometry. The project has shown that this measurement can be accomplished routinely in a mill setting, in the presence of dirt, water spray, temperature extremes, and vibration. Use of this system on a production line began in March 2002. As of September 2003, over 600,000 tubes have been measured. Savings from system deployment are exceeding projections. A major savings is reduced scrap. Use of this system has contributed to attainment of record low tube scrap rates. Annual energy savings in tube-making due to this installation have been estimated at 5 percent, or 50 billion Btus. Commercialization efforts are underway and quotes are being provided in response to industry interest.

Diode Laser Sensor for Combustion Control – American Air Liquide has developed a tunable diode laser sensor for detecting temperature, NO_x levels, and CO levels in harsh furnace environments. The sensing system can also measure the oxygen content in the furnace combustion gases, which has been difficult to accomplish using laser absorption spectroscopy. All of these data will help furnace operators optimize their combustion processes, thereby increasing efficiency and reducing emissions of criteria pollutants and CO_2. In FY 2003, the technology developers worked with host companies in the steel and aluminum industries to demonstrate the new sensor, which has wide application across these and many other industries. More work with the steel industry is planned for the upcoming year.

In-Situ, Real-Time Measurement of Melt Constituents – Energy Research Company has developed a laser-induced breakdown spectroscopy technology that measures melt constituents in-situ and in real-time. The technology, which was developed for use in the recycled aluminum industry, accurately measures the melt composition at any point in the melt. A demonstration at a Commonwealth Aluminum facility was conducted in the summer of 2003. At least one unit of the new technology has already been purchased and additional applications are anticipated in the glass, steel, and utility industries.

Intelligent Extruder – A software system for monitoring and controlling extruders used in polymer injection molding has been developed and demonstrated on laboratory scale. The new control system, which uses available low-cost sensors and data derived from the production process, reduces production variability and thus off-grade waste generation. In FY 2003, the algorithms were validated using commercial production rate data, demonstrating that the system's diagnostics and control concepts are extensible to production-scale operations.

Exhibit 5
Phase II SBIR Projects Co-Directed by S&A in FY 2003

- Fiber-Optic Sensor for Industrial Process Measurement and Control (Combustion Control and Temperature Measurement)
- Portable Parallel Beam X-Ray Diffraction System (Steel)
- Cavity-enhanced Gas Analyzer for Process Control Applications
- Broadly Tunable Mid-Infrared Hydrocarbon Sensor

Wireless Telemetry for Industrial Applications – The development of a network architecture (integrating principle) for using wireless telemetry technology in industrial environments was the focus of this project conducted by Oak Ridge National Laboratory. Multiple prototype wireless systems have been developed and demonstrated at a Timken steel plant and at least one paper mill. The new architecture addresses some of the biggest challenges facing the use of wireless technology in industry – reliability, ease-of-use, cost-effectiveness, and standardization of communication protocols.

Fiber-Optic Sensor for Industrial Process Measurement and Control – The goal of this SBIR Phase II project is to develop a tunable diode laser absorption spectroscopy instrument for practical use in combustion applications. The technology is less intrusive, more accurate, and more flexible than currently used extractive sampling techniques. The developer, MetroLaser, has achieved solid results in FY 2003, with the prototype sensor including tests in a 1.5 MW boiler and tests to measure temperature associated with the manufacture of fiber optic cable.

Cavity-enhanced Gas Analyzer for Process Control Applications – Los Gatos Research is developing an alternative to gas chromatography for measuring acetylene contamination during ethylene production in this Phase II SBIR project. Several technologies were evaluated, with only a new ultra-sensitive, cavity-enhanced absorption process providing sufficient sensitivity in a robust package. A prototype unit was tested in FY 2003, yielding accurate and reproducible measurements of acetylene content. Field testing of the technology for measuring acetylene is continuing and the application of the technology in petrochemical manufacturing, semiconductor manufacturing, and oil drilling is being considered. Testing at a Dow chemical plant is currently planned.

Broadly Tunable Mid-IR Hydrocarbon Sensor – This SBIR Phase II project is developing a broadly tunable mid-IR laser spectrometer that can be used in the chemical industry for measuring the concentration of chemical species, measurements that can be used both to control chemical manufacturing processes and monitor plant emissions. Physical Sciences, Inc., together with Dow and Analytical Specialties, Inc., is developing this system with the goal of increasing chemical process energy efficiency.

Exhibit 6
Examples of Other ITP Projects Relevant to Sensors & Automation

Aluminum Projects
- Intelligent Potroom Operation

Chemicals Projects
- Near-Infrared Spectropolarimetry for On-Line Measurement of Polymer Rheology
- Corrosion Monitoring System

Forest Products Projects
- 4-D Characterization of Paper Web at the Wet End
- Linescan Camera System for On-Line Moisture Measurement
- Distributed Web Sensor for On-Line Measurement of Paper Basis Weight-Mill Demonstration Phase
- Non-Contact Laser Acoustic Sensor for On-Line Measurement of Paper Stiffness
- Laser-Ultrasonic Web Stiffness Sensor
- Detection and Control of Deposition on Pendant Tubes of Kraft Chemical Recovery Boilers
- On-Line Fluidics Controlled Headbox with Coanda Jet
- Wood Chip Moisture Content
- A Real-Time On-Line Ultrasonic Sensor to Measure Pulp Consistency and Degree of Refining
- Guided Acoustic Wave Monitoring of Corrosion and Erosion Monitoring in Recovery Boiler Tubing
- Field Mobile NIR for Standing Wood
- Laser Sensors for On-Line Monitoring of Carryover in Recovery Boilers
- Model-Based Approach to Soft Sensing and Diagnosis for Control of a Continuous Digester
- Evaluation and Development of a Prototype Electrokinetic Sonic Amplitude (ESA) System for On-Line Measurement of Zeta Potential in Papermaking Process Streams
- Wireless Microwave Wood Moisture Measurement System for Wood for Wood Drying Kilns
- CFD Modeling, Shape Optimization and Feasibility Testing of Advanced Black Liquor Nozzle

Glass Projects
- Measurement and Control of Glass Feedstocks
- Advanced Process Control for Glass Production
- Auto Glass Process Control

Metalcasting Projects
- Sensors for Die Casting

Mining Projects
- Mine Compatible Laser Analysis Instrument for Ore Grading
- Robotics for Improving Mining Productivity
- Calibration Methods for On-line Analyzers
- Horizon Sensing

Petroleum Projects
- Micro-Gas Chromatography Controller
- Gas Imaging for Advanced Leak Detection

Steel Projects
- In-Situ, Real-Time Measurement of Melt Constituents
- Optical Sensor for Post-Combustion Control in EAF Steelmaking
- Real-Time Melt Temperature Measurement in a Vacuum Degasser Using Optical Pyrometry
- Automated Steel Cleanliness Analysis Tool
- Standard Methodology for Measurement of Steel Phase Transformation Kinetics Using Dilatometrics
- Hydrogen and Nitrogen Control in Ladle and Casting Operations

Inventions and Innovation Projects
- Fiber-Sizing Sensor/Controller for Optimizing Glass and Polymer Fiber Manufacturing Processes
- Temperature Measurement in Hostile Environments with Microwave Radiometry
- Wireless Telemetry for Mine Monitoring and Emergency Communications

NICE^3 Projects
- Method of Inspecting On-Stream Process Piping at Support Areas for Refineries and Chemical Plants
- Lumber Defect Detection System
- An Automatic Inspection-Based Process Advising System for Steel Products at High Temperature

Partnership Highlights

Industrial Wireless Vision – Over 30 individuals representing the extended industrial wireless community have cooperatively developed *Industrial Wireless Technology for the 21st Century*, a unified vision for the future of this rapidly evolving technology. The resulting document (December 2002) is now available on the EERE Web site. The vision defines specific goals and challenges, provides some context for non-experts, and maps out the key hurdles to fully exploiting wireless capabilities in industrial environments.

DOE sponsored the Industrial Wireless Workshop in July 2002 as a forum for the industrial wireless community to articulate long-term goals. Their input will be valuable in designing collaborative efforts for the development of industrial wireless sensor systems and may prove useful in other application areas such as auto assembly, building management, transportation systems, and power generation.

WINA Strategy Workshop – Sensors & Automation is assisting suppliers and end-users of industrial wireless technology with the creation of WINA, the Wireless Industrial Networking Alliance. WINA's major objective is to promote the adoption of wireless networking technologies and practices that will help increase industrial productivity and efficiency. In September 2003, S&A participated in the first WINA strategy workshop held in Coral Gables, Florida. More than 35 end users, suppliers, system integrators, and other stakeholders came together to help devise a strategy to increase industrial adoption of wireless technology.

Improving Energy Efficiency Today

Technology Delivery Program – Sensors & Automation focuses on mid- to long-term technology research. EERE/ITP's Technology Delivery Program offers other products and services to assist industry in saving energy in the near-term. These products and services include software tools and associated training to improve the efficiency of plant utility systems, cost-shared plant assessments, no-cost plant audits for small and mid-size companies, and numerous helpful publications describing applications of good plant operating practices. Activities such as these have the potential to save the steel industry millions of dollars annually. To learn more, please visit http://www.oit.doe.gov/bestpractices. For more information on the no-cost audits, visit http://www.oit.doe.gov/iac.

Mining Industry Sensors and Automation Evaluation – As part of the activities leading up to the August 2003 Mining Energy Solutions event, walk-through evaluations of the sensor and automation systems at two gold mines near Elko, Nevada were conducted.

Disseminating Research Results

Sensors & Automation Web Site – The Sensors & Automation Web site is a valuable tool for disseminating information on the portfolio's activities. The Web site highlights R&D projects, provides access to EERE publications, and notes upcoming solicitations. The Web site also contains a "News" section that provides articles on recent events, updates on research successes, and notification about new software tools and other services of potential interest to manufacturers and users of sensor and control systems technology. It also includes contractor presentations from the most recent annual portfolio review meetings.

***R&D 100 Awards* –** The new mining horizon sensor technology developed with EERE funding won one of the prestigious *R&D 100 Awards* announced by *R&D Magazine* in October 2002. The new sensing system provides real-time analysis of the thickness of coal in the floors and roofs of mines and the locations of dangerous abandoned mines parallel to active ones.

Energy Analysis - Targeting Energy Efficiency

Sensors & Automation Project Evaluation Tool – An interactive software tool was created to help applicants to Sensors & Automation solicitations analyze the potential energy and environmental benefits of their technologies. This on-line tool allows for standardized analysis of the proposed projects, which facilitates selection of the best technologies for funding. Applicants to S&A solicitations are now required to use the tool.

GPRA Analysis – This annual exercise was completed for projects considered in the FY 2005 budget. The GPRA analysis estimates future benefits of emerging technologies in the Sensors & Automation portfolio based on market penetrations, energy savings, and environmental emission reductions.

Assessment Study on Sensors & Automation in the Industries of the Future – Teams of experts in the areas of controls, automation, robotics, and information processing have conducted broad analyses of the state of the art in these four areas of interest to S&A. The results of the study include lists of the top energy-saving R&D opportunities in each area, the industrial sectors with the greatest needs, and estimates of the potential energy savings that could be achieved. The study will help guide S&A in soliciting proposals for funding projects that could have the greatest impact on reducing industrial energy consumption.

TOOLS, PUBLICATIONS, AND RESOURCES AVAILABLE

EERE offers valuable tools and publications to help companies improve productivity and energy efficiency. Some of these resources are described below. See the Web site at http://www.oit.doe.gov/sens_cont for a complete listing.

Fact Sheets – Publications describing R&D projects, emerging technologies, and commercial successes are available on the Web site.

Industrial Wireless Technology for the 21st Century – Over 30 individuals representing the extended industrial wireless community have cooperatively developed a unified vision for the future of this rapidly evolving technology. The vision document defines specific goals and challenges, provides some context for non-experts, and maps out the key hurdles to fully exploiting wireless capabilities in industrial environments.

Project Evaluation Tool – Software is available at http://www.energetics.com/sensor_tool that can be used to estimate the potential energy and environmental benefits of a proposed new measurement or control technology.

Corporate Brochure – The EERE/ITP corporate brochure, *Results for Today, Leadership for Tomorrow*, provides an overview of ITP and the collaborations, partnerships, tools, resources, and opportunities available to the nation's essential, energy-intensive industries. The brochure and similar overview publications can be found at http://www.oit.doe.gov/aboutoit/brochures.shtml.

HOW TO GET INVOLVED AND CONTACT INFORMATION

Partnership Information

Public-private partnerships are the foundation of ITP's technology delivery strategy. ITP includes its partners in every phase of the technology development process to focus scarce resources where they can have the greatest impact on industrial energy efficiency. To learn more, please visit our Web site at www.eere.energy.gov/industry.

- Collaborative, **cost-shared research and development** projects are a central part of ITP's strategy. Annual solicitations provide technology development opportunities in a variety of energy-intensive industries.

- **Industries of the Future Partnerships** increase energy efficiency in the most energy-intensive industries. In addition to cost-shared research and development projects, industry partners participate in the development of vision and roadmap documents that define long-term goals, technology challenges, and research priorities.

- **Allied Partnerships** provide an opportunity for ITP to reach a broad audience of potential customers by allying with corporations, trade associations, equipment manufacturers, utilities, and other stakeholders to distribute industrial energy efficiency products and services. By becoming an Allied Partner, an organization can increase its value to clients by helping them achieve plant efficiencies.

- **State energy organizations** work with ITP in applying technology to assist their local industries. ITP assists states in developing IOF partnerships to mobilize local industries and other stakeholders to improve energy efficiency through best practices, energy assessments, and collaborative research and development.

- **EERE's technical programs** (of which ITP is one of eleven) give manufacturers access to a diverse portfolio of energy efficiency and renewable energy technologies and bring advanced manufacturing technology to the renewable energy community. For more information, access the EERE home page at www.eere.energy.gov.

- The President's **Climate VISION** (Voluntary Innovative Sector Initiatives: Opportunities Now) effort also offers opportunities for manufacturers to pursue cost-effective actions that will reduce greenhouse gas emissions. See www.climatevision.gov for details.

Access to Resources and Expertise

The Industrial Technologies Program provides manufacturers with a wide variety of industrial energy efficiency resources to help your company cut energy use right away. Visit our site at www.eere.energy.gov/industry or call the EERE Information Center at 877-337-3463 to access these resources and for more information.

- ITP offers **energy management best practices** to improve energy efficiency throughout plant operations. Improvements to industrial systems such as compressed air, motors, process heat, and steam can yield enormous savings with little or no capital investment.

- Our suite of powerful system optimization **software tools** can help plants identify and analyze energy-saving opportunities in a variety of systems.

- **Training sessions** are held several times per year at sites across the country for companies interested in implementing energy-saving projects in their facilities. DOE software tools are used as part of the training sessions.

- ITP's qualified **industrial energy specialists** will work with your plant personnel to identify savings opportunities and train staff in the use of ITP software tools.

- Our extensive library of **publications** gives companies the resources they need to achieve immediate energy savings.

- **Plant-wide energy assessments** are available to manufacturers of all sizes interested in cutting their energy use. Cost-shared solicitations are available each year for plant-wide energy assessments. In addition, no-cost, targeted assessments are provided to eligible facilities by teams of engineering faculty and students from 26 university-based Industrial Assessment Centers around the country.

- The **DOE Regional Offices** provide a nation-wide network of capabilities for implementing ITP's technology delivery strategy. Regional Offices are located in Atlanta, Boston, Chicago, Denver, Philadelphia, and Seattle. Visit www.eere.energy.gov/rso.html for more information.

Where to Go to Get More Information

Visit our Web site - www.oit.doe.gov/sens_cont

Learn about all EERE programs - www.eren.doe.gov

Ask an Expert - The Industrial Technologies Program's Clearinghouse is a great way to access ITP's resources. Times available are 9 a.m. to 8 p.m. EST (6 a.m. to 5 p.m. PST).
Phone: 1-800-862-2086
Fax: 360-956-2214
Email: clearinghouse@ee.doe.gov

For print copies of DOE, EERE, and ITP Publications, contact -
Energy Efficiency and Renewable Energy Clearinghouse (EREC)
P.O. Box 3048
Merrifield, VA 22116
Fax: 703-893-0400
Phone: 800-363-3732
Email: doe.erec@nciinc.com

For questions regarding Sensors & Automation activities, please contact -
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A Strong Energy Portfolio for a Strong America

Energy efficiency and clean, renewable energy will mean a stronger economy, a cleaner environment, and great energy independence for America. By investing in technology breakthroughs today, our nation can look forward to a more resilient economy and secure future.

Far-reaching technology changes will be essential to America's energy future. Working with a wide array of state, community, industry, and university partners, the U.S. Department of Energy's Office of Energy Efficiency and Renewable Energy invests in a portfolio of energy technologies that will:

- Conserve energy in the residential, commercial, industrial, government, and transportation sectors
- Increase and diversify energy supply, with a focus on renewable domestic sources
- Upgrade our national energy infrastructure
- Facilitate the emergence of hydrogen technologies as a vital new "energy carrier"

The Opportunities

Biomass Program
Using domestic, plant-derived resources to meet our fuel, power, and chemical needs

Building Technologies Program
Homes, schools, and businesses that use less energy, cost less to operate, and ultimately, generate as much power as they use

Distributed Energy & Electric Reliability Program
A more reliable energy infrastructure and reduced need for new power plants

Federal Energy Management Program
Leading by example, saving energy and taxpayer dollars in federal facilities

FreedomCAR & Vehicle Technologies Program
Less dependence on foreign oil, and eventual transition to an emissions-free, petroleum-free vehicle

Geothermal Technologies Program
Tapping the Earth's energy to meet our heat and power needs

Hydrogen, Fuel Cells & Infrastructure Technologies Program
Paving the way toward a hydrogen economy and net-zero carbon energy future

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry through improvements in energy and environmental performance

Solar Energy Technology Program
Utilizing the sun's natural energy to generate electricity and provide water and space heating

Weatherization & Intergovernmental Program
Accelerating the use of today's best energy-efficient and renewable technologies in homes, communities, and business

Wind & Hydropower Technologies Program
Harnessing America's abundant natural resources for clean power generation

To learn more, visit www.eere.energy.gov

Sensors & Automation

Industrial Technologies Program
Boosting the productivity and competitiveness of U.S. industry

U.S. Department of Energy
Energy Efficiency and Renewable Energy

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